WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: 2005AZ90B

Title: An Outdoor Multi-Stage, Continuous-Flow Photobioreactor for Bioremediation of Nitrate-Contaminated Groundwater

Project Type: Research

Focus Categories: Groundwater, Nitrate Contamination, Treatment

Keywords: Nitrate contamination, nutrient removal, algae, photobioreactor, biological treatment, public health

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Non-Federal Matching Funds: $45,123

Congressional Districts: 5, 6

Principal Investigators:
Qiang Hu

Milton Sommerfeld

Abstract

Arizona relies heavily on groundwater, which represents more than 40% of the state's drinking water supply resource. Numerous wells across the state, and particularly those in metro Phoenix and Tucson areas where large land areas were extensively used for decades for agricultural and industrial activities, exceed the US EPA mandated maximum contaminant level of 10 mg L-1 for nitrogen as nitrate in drinking water. Long-term consumption of groundwater containing high levels of nitrate may pose serious health risks, including "blue baby syndrome" in babies and medical complications and carcinogenesis in adults. Several conventional chemical and physical technologies have been proposed or tested for groundwater nitrate removal. However, the projected high capital and operational costs have prohibited commercial applications of these approaches. We propose to use an innovative photobioreactor to remove nitrate and possibly other contaminants from groundwater while concomitantly producing renewable biomass. Two critical challenges to this concept have been identified: 1) finding high performing microalgal species that can thrive in groundwater and take up nitrate at rates

substantially higher than those previously reported; and 2) developing a large-scale photobioreactor to accelerate the biological process in a sustainable manner. In a previous Water Resources Research Center research grant (Grant No. 01-HO-GR-0113), we successfully isolated four high-performance microalgal species and demonstrated that one of the species, a Scenedesmus strain, can remove 50 mg L-1 nitrate as nitrogen from groundwater within 24 hours. In this proposed research, we will focus on the second challenge, i.e., development of a highly efficient, cost-effective photobioreactor. A Multiple-stage, Continuous-Flow Photobioreactor (MCP) will be designed, fabricated, and operated in a batch, semi-continuous, or continuous mode under outdoor conditions. The high-performance Scenedesmus strain will be used as a model organism to evaluate the performance of microalgae in MCP and further determine the environmental factors (such as light intensity, temperature, and culture retention time) affecting the cell growth and nitrate removal rate. An optimal maintenance protocol for sustainable maximum nitrate removal and a technical design for a field pilot-scale photobioreactor will be developed. It is anticipated that the proposed MCP could not only be used as a centralized facility for large cities such as Phoenix and Tucson, but also be suitable, once scaled down, for small communities in remote areas. Furthermore, algal biomass produced as a by-product from the photobioreactor can be used as an organic fertilizer or animal feed, which would provide additional value to this advanced environmental clean-up green biotechnology.